

Coronal Fractures of the Scaphoid: A Review

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Abstract

Keywords

- scaphoid
- fracture
- coronal

Coronal (or frontal plane) fractures of the scaphoid are distinctly uncommon. There are few published reports of coronal fractures of the scaphoid. This fracture is often missed on the initial X-ray films. A high index of suspicion should exist when there is a double contour of the proximal scaphoid pole on the anteroposterior X-ray view. A computed tomography scan is integral in making the diagnosis. Early recognition is key in salvaging the scaphoid fracture and in preventing articular damage.

Level of Evidence IV. Retrospective case series.

Russe et al¹ described a vertical, oblique scaphoid fracture relative to the long axis of the scaphoid on an anteroposterior X-ray view. Vertical oblique fractures are rare and are considered the most unstable. In one radiographic study only one vertical oblique fracture was seen in 442 scaphoid fractures.² The Russe classification, however, did not take into account fractures in the frontal plane. A coronal fracture cleaves the scaphoid into a volar and a dorsal fragment along the frontal axis of the scaphoid, which is 90 degrees relative to the usual fracture plane.

Coronal fractures of the scaphoid are distinctly uncommon with few published reports.^{3–7} In the French language literature, Schernberg et al proposed a classification that did include a diagram of a trans tuberosity coronal fracture through the middle third of the scaphoid, which he classified as a type IV fracture.⁸ Coronal fractures are often missed on

the initial X-ray films. Our purpose is to present a case series demonstrating the variability in the types of coronal plane fractures and to propose a classification and an algorithm for treatment.

Case Series

Case 1. Complete Coronal Fracture

A 35-year-old man presented to D. S. with dorsal wrist pain, 5 weeks following a fall onto an outstretched hand. The patient had tenderness over the dorsal aspect of the scaphoid and a painful scaphoid shift test. The initial anteroposterior (AP) X-ray showed a double contour of the proximal pole (►Fig. 1 A) but no obvious scaphoid fracture and a normal scapholunate angle on the lateral X-ray view. The scapholunate gap appeared normal at 2 mm. A computed tomography

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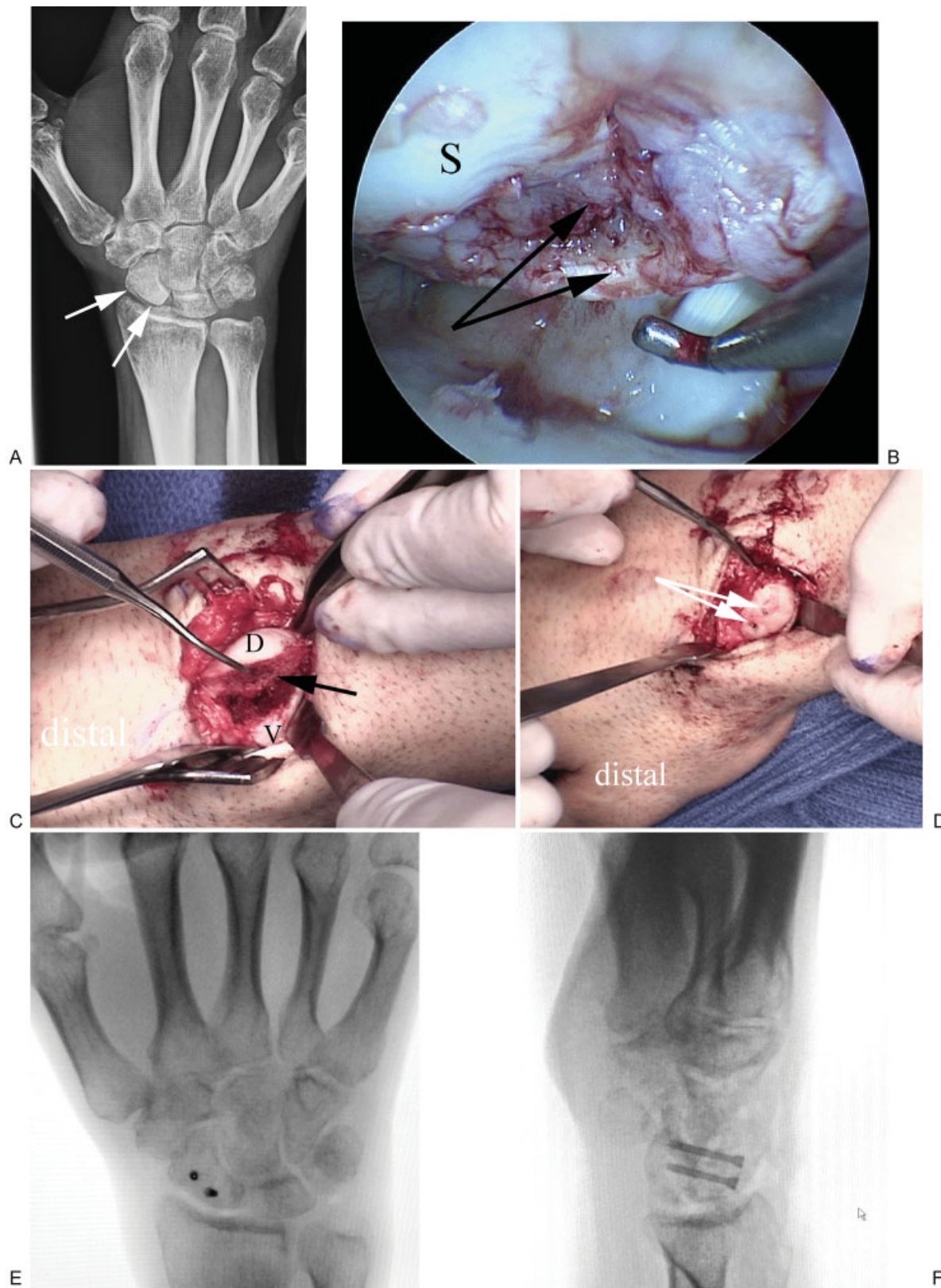


Fig. 1 (A) Anteroposterior X-ray view of the right wrist demonstrating a double contour of the proximal pole of the scaphoid (arrows). (B) Arthroscopic view of the proximal scaphoid from the 3,4 portal. Arrows are highlighting the malunion site and the step-off of the proximal articular surface. (C) Intraoperative view of the dorsal aspect of the right wrist. The scaphoid fracture is being pried apart and opened like a clam shell, demonstrating the dorsal (D) and volar (V) fracture fragments. (D) Internal fixation of scaphoid with two horizontal headless screws (arrows). (E) Postoperative anteroposterior X-ray view of the right wrist demonstrating disappearance of the double contour of the proximal pole of the scaphoid. Note that the screws appear as small circles since they are passing from a dorsal to volar position. (F) Postoperative lateral X-ray view of the right wrist demonstrating the headless screws that are passing from a dorsal to volar position.

(CT) scan revealed a coronal split of the scaphoid. He was taken to the operating room where diagnostic arthroscopy revealed a malunited coronal fracture along the entire length of the scaphoid with a significant articular step-off both at the radiocarpal joint and the midcarpal joint (►Fig. 1 B). The scapholunate interosseous ligament (SLIL) was still well attached to the dorsal fragment. The scaphoid was approached dorsally between the 3rd and 4th extensor compartments. The fracture was pried apart with Freer elevators (►Fig. 1 C). Both the dorsal and volar fracture fragments appeared viable, with healthy vascularized cancellous bone and punctate bleeding. Two separate 1.7 mm headless screws were inserted from a dorsal to volar direction, and the screw heads were buried under the articular cartilage (►Fig. 1 D). The postoperative AP view showed a normal appearing scaphoid with disappearance of the double contour of the proximal pole (►Fig. 1 E,F). The ultimate fate of this fracture, however, is unknown since the patient failed to appear for follow-up.

Case 2. Partial Coronal Fracture of the Distal Pole

A 44-year-old man presented to D. R. with wrist pain after a fall onto an outstretched left hand presented with wrist pain following fall. The X-rays and CT were consistent with an undisplaced distal partial coronal fracture of the proximal pole (►Fig. 2 A-D). The patient was treated in short arm cast. At 8 weeks, the fracture had remained in satisfactory position, but was lost to follow-up.

Case 3. Partial Coronal Fracture of the Proximal Pole

C. S. M. described the case of a 36-year-old man who presented with a right wrist injury after punching a hard object. X-rays showed an undisplaced waist fracture with proximal extension into the proximal pole (Fig. 3 A). A CT scan showed a proximal partial coronal fracture that started off in the axial plane and then goes into the coronal plane (►Fig. 3 B,C). The patient was treated in a long-arm thumb spica cast for 4 weeks followed by a short-arm cast for 4 weeks. The fracture healed but the patient was lost to follow-up.



Fig. 2 (A) Anteroposterior X-ray of a partial coronal fracture of the distal scaphoid (arrow). (B) Anteroposterior computed tomographic scan of a partial coronal fracture of the distal scaphoid (arrow). (C) Lateral computed tomography scan of a partial coronal fracture of the distal scaphoid demonstrating a horizontal distal fracture line and proximal coronal fracture line (arrow). (D) Axial computed tomography scan of a partial coronal fracture of the distal scaphoid (arrow).

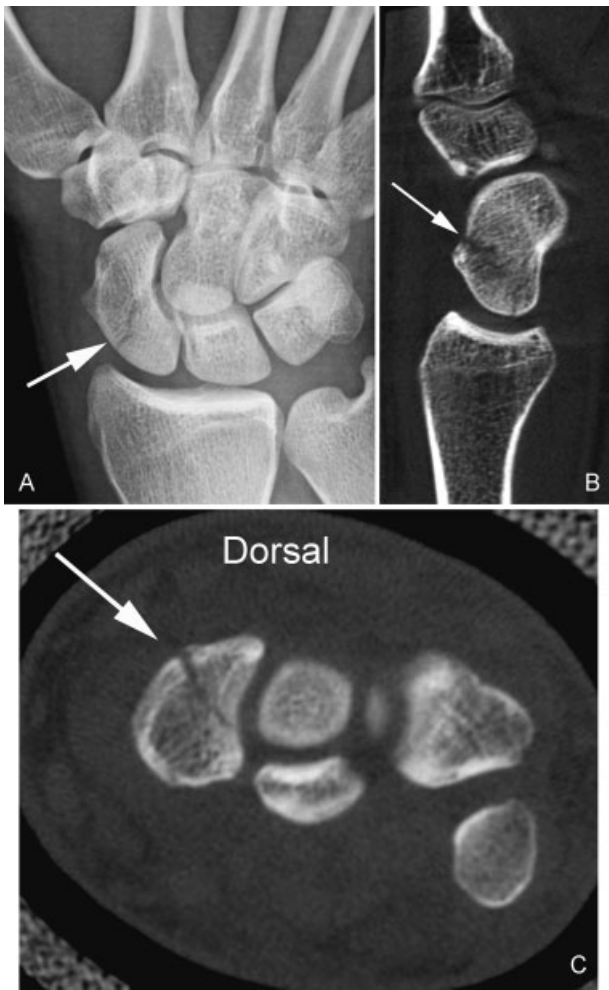


Fig. 3 (A) Undisplaced waist fracture with proximal extension into the proximal pole (arrow). (B,C) computed tomography scan shows a proximal partial coronal fracture that starts off in the axial plane and then goes into the coronal plane (arrows) (Figure 3 B,C).

Case 4. Coronal Nonunion of the Proximal Pole

A 17-year-old adolescent boy presented to the emergency department with immediate right-sided wrist pain after punching a boxing ball. X-rays revealed a proximal scaphoid fracture which was immobilized for 12 weeks. Follow-up radiographs were interpreted as showing fracture union, but no CT scan was performed. Nine years later, he was referred to G. B. with right-sided wrist pain. A CT scan showed a proximal partial coronal fracture nonunion (→Fig. 4 A,B). The fracture angle relative to the central scaphoid axis was calculated to be 65 degrees. The patient was treated with a proximal row carpectomy, posterior interosseous nerve neurectomy, and a radial styloidectomy because of painful osteoarthritis (OS).

Case 5. Coronal Waist Fracture with Perilunate Injury

A. S. describes the case of a 58-year-old male multiple trauma patient who presented after a motor vehicle accident with a pelvic fracture plus a wrist injury. AP X-rays revealed a scaphoid waist fracture, plus a small radial styloid avulsion fracture, dorsal triquetral avulsion and the 3rd metacarpal base fracture (→Fig. 5 A). The axial CT scan revealed a coronal waist fracture (→Fig. 5 B). The patient was taken to the operating room 1 week after stabilization of his pelvic fracture. He underwent an open reduction internal fixation of the coronal scaphoid fracture with two dorsal to volar cannulated screws plus a repair and pinning of the lunotriquetral ligament (→Fig. 5 C). The Kirschner (K)-wires were removed at 10 weeks followed by motion. At the 12-month follow-up the scaphoid fracture was healed. The wrist flexion was 55 degrees and extension 55 degrees.

Case 6. Coronal Waist Fracture with Perilunate Dislocation

G. H. treated a 44-year-old man presenting with a trans-scaphoid volar perilunate dislocation after a fall from a roof onto a hyperflexed wrist (→Fig. 6 A). A CT scan revealed a

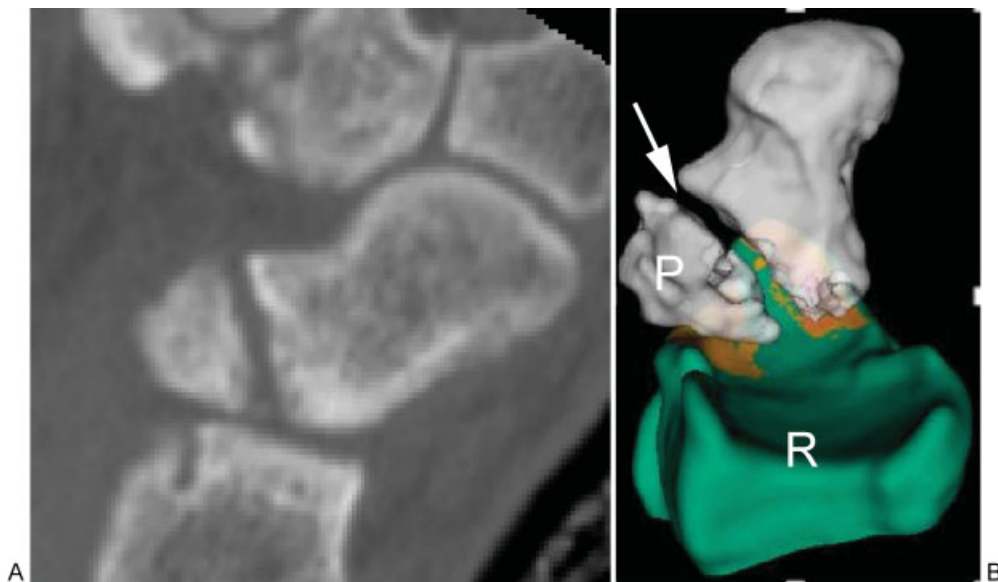


Fig. 4 (A) Lateral computed tomographic scan showed a proximal partial coronal fracture nonunion. (B) Three-dimensional reconstruction highlighting the nonunion and fracture plane at 65 degrees (arrow). P, proximal scaphoid pole; R, radius.

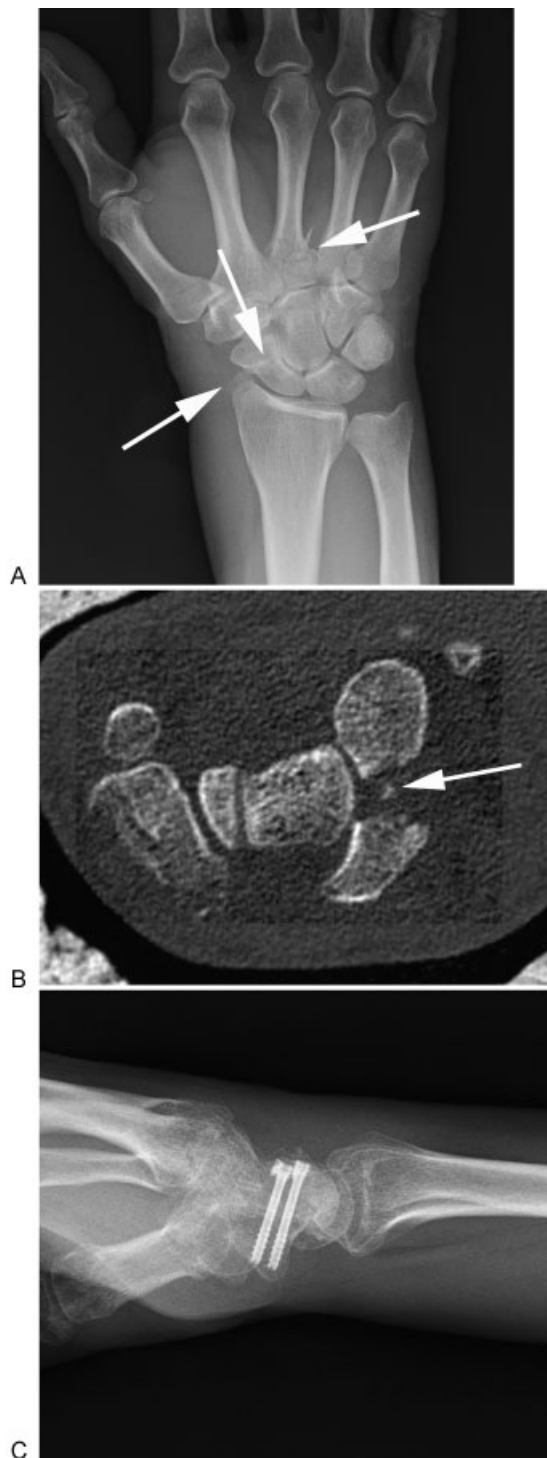


Fig. 5 (A) Anteroposterior X-rays demonstrating a scaphoid waist fracture, plus a small radial styloid avulsion fracture, dorsal triquetral avulsion, and the 3rd metacarpal base fracture (arrows). (B) Axial computed tomography scan revealed a coronal waist fracture (arrow). (C) An open reduction internal fixation of the coronal scaphoid fracture with two dorsal to volar cannulated screws.

coronal waist fracture of the scaphoid and perilunate dislocation (►Fig. 6 B). The patient underwent screw fixation of the scaphoid through a volar approach and radiolunate pinning. The K-wires were removed at 6 weeks. At a 1-year

follow-up, (►Fig. 6 C,D) the patient had pain with effort, especially with the wrist in flexion. Wrist flexion was 20 degrees, extension 45 degrees, and grip strength was 70% of the opposite wrist.

Discussion

Coronal fractures of the scaphoid represent an uncommon subset of scaphoid fractures. These fractures are often missed, which can lead to poor outcomes. This case series demonstrates the spectrum of injury and different management options. Although there is a paucity of literature on this unusual fracture pattern, a few common elements have emerged. The coronal fractures can be complete and involve the entire body of the scaphoid. This should be suspected when there is a double contour of the proximal scaphoid pole on the AP X-ray view, which has been termed the proximal ring sign by Herzberg et al.³

The SLIL can be completely detached or split into a dorsal and volar half. In some instances, reduction of the fracture fragments restores the integrity of the ligament whereas in other cases a scapholunate ligament repair may be necessary. Shin et al⁴ published a case of a complete coronal scaphoid fracture in a 17-year-old male hockey player. At the time of surgery a complete SLIL tear was found along with a concomitant coronal fracture of the scaphoid. This was treated with a dorsal to volar cannulated screw and a scapholunate ligament and a temporary scapholunate screw. At 16 months, the patient was pain-free with normal wrist motion and a completely healed scaphoid fracture with a normal scapholunate interval.

Herzberg et al³ published two cases of coronal fractures of the scaphoid involving the proximal pole. The first case was a 33-year-old male truck driver presenting with a 2-month-old wrist injury. The X-rays appeared normal, save for a proximal ring-shaped overlap of the cortices on the AP ulnar-deviated view. A lateral CT scan showed a displaced coronal fracture of the proximal scaphoid. At surgery, the dorsal part of the proximal scaphoid had fractured off the rest of the bone, and there was a 2 mm cartilage step-off. The SLIL was intact, but its dorsal part was attached to the displaced scaphoid fragment. The fracture fragment was fixed with 1.5 and 2.0 mm screws inserted in the sagittal plane. A short-arm cast was applied for 2 months, followed by rehabilitation and a return to manual labor. At 9 years, the patient was pain-free with wrist flexion of 30 degrees and extension of 50 degrees. AP X-rays demonstrated slight radial styloid narrowing. Their second case was that of a 25-year-old painter who presented, at 3.5 months, with a painful wrist after punching a bag. He also had a proximal scaphoid ring sign and a coronal fracture of the proximal pole on the lateral CT scan view which demonstrated fracture displacement in both the sagittal and transverse planes. The patient was operated on 4 months after his injury through a dorsal approach. The dorsal part and the proximal scaphoid, including its dorsal ridge, was found to be significantly displaced, but the dorsal and proximal parts of the SLIL were intact, and still attached to the displaced scaphoid fragment. There was a partial rupture of the palmar



Fig. 6 (A) Transscaphoid volar perilunate dislocation. (B) Three-dimensional computed tomography reconstruction revealed a coronal waist fracture of the scaphoid and perilunate dislocation. pp, proximal pole; dp, distal pole. (C,D) One-year follow-up demonstrating a healed fracture and horizontal volar screw position.

SLIL. The fragment was reduced and fixed with two K-wires without bone graft and the palmar SLIL ligament tear was left untreated. A short-arm cast was applied for 3 months, after which the K-wires were removed. The patient had a pain-free wrist at a 9-year follow-up with wrist flexion of 75 degrees

and extension of 70 degrees. AP X-rays showed slight osteolysis of the very proximal scaphoid without collapse and no carpal instability. Ng et al⁶ also published the case of a 25-year-old man with a coronal fracture of the proximal pole. The fracture was exposed dorsally between the extensor pollicis longus and the extensor carpi radialis brevis and longus. The scapholunate ligament was intact. The dorsal fragment was fixed with two headless compression screws from dorsal to volar. At 16 months postoperatively, the patient's right wrist was pain-free with flexion 80 degrees and extension 75 degrees. X-rays showed complete healing of the fracture with no sign of avascular necrosis.

Vidil and Dumontier⁵ published their experience with a coronal fracture of the proximal pole in two patients following high-energy trauma. Their first patient was a 29-year-old, right-handed, man involved in a motorcycle accident. The initial X-rays were reported as normal. A CT scan performed at 4 weeks, however, revealed a non-displaced fracture of the proximal end of the proximal pole. The patient was immobilized in a plaster cast for 4.5 months. At 11 years, he had

Table 1 Coronal plane fracture classification

Coronal fracture: complete
i) with partial scapholunate interosseous ligament tear
ii) with complete scapholunate interosseous ligament tear
Coronal fracture: partial
i) i distal pole
ii) waist
iii) proximal pole
Coronal fracture with perilunate injury

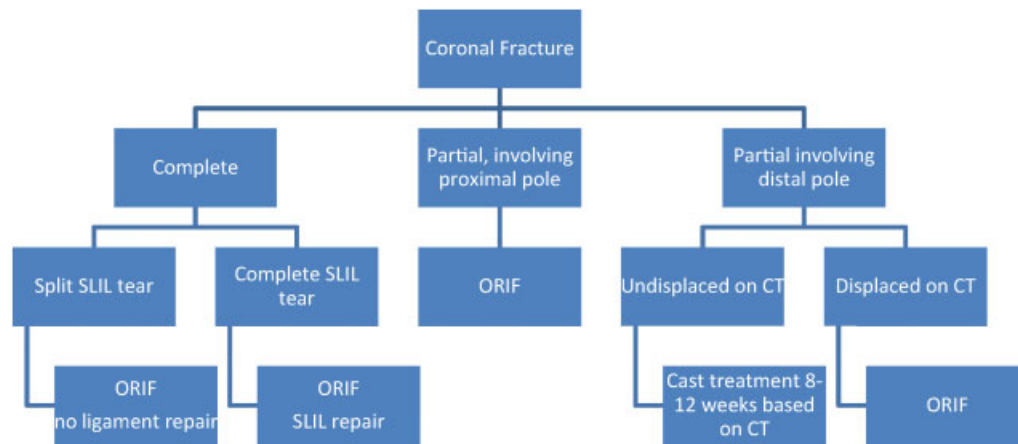


Fig. 7 Algorithm.

normal X-rays without wrist pain nor functional limitations. Their second case was a 34-year-old man with multiple trauma due to a motorcycle accident. He presented, at 8 months, with a painful wrist and double contour of the proximal pole of the scaphoid plus a dorsal intercalated segmental instability. At the time of surgery, he was found to have a malunited coronal fracture of the proximal pole and a scapholunate ligament tear which was treated with a proximal row carpectomy. This is similar to case 4.

The coronal fracture can be partial and involve either the proximal pole (case 2) or distal pole (case 4). In these cases the fracture line has both a coronal and transverse component. This is keeping with a study by Luria et al⁹ who performed three-dimensional CT scans of 124 scaphoid fractures and concluded that practically all fractures were horizontal oblique, and not transverse. Case 3 demonstrates a partial coronal fracture of the distal pole.

Coronal fractures can also be seen in association with a perilunate injury (Case 5 and 6). Shin and Shin⁷ also published the case of a 16-year-old adolescent girl who presented with a transscaphoid, translunate, and trans-triquetral perilunate injury. The CT scan revealed coronal fractures of the scaphoid, lunate, and triquetrum and an oblique fracture through the base of the ulnar styloid. Treatment involved an open reduction and internal fixation of the fractures followed by wrist immobilization. At 15 months follow-up, grip strength and motion were diminished compared with the uninjured wrist. X-rays demonstrated that all of the fractures were healed but with capitolunate joint space narrowing.

Because of the limited number of patients and incomplete follow-up it is not possible to make firm treatment recommendations. We believe, however, that all complete coronal fractures and displaced partial coronal fractures that involve the proximal pole should be treated operatively. Proximal pole fractures are likely to be highly unstable with an increased risk of nonunion and prolonged healing time.¹⁰ Dorsal to volar screw fixation is preferred since higher fixation stability is achieved when the scaphoid is fixated perpendicular to the fracture especially in oblique-type

fractures. Undisplaced partial coronal fractures of the distal pole can be treated with casting since they appear to have a good tendency to heal.

Both complete and partial malunions may lead to radio-carpal OA and may require a salvage procedure but our data are too limited to state this with certainty. Perilunate injuries most likely represent a different cohort of patients in which the outcomes are influenced both by the associated ligamentous injury and additional carpal bone involvement. The coronal nature of the scaphoid fracture line, however, and higher risk of an SLIL tear has implications with regards to surgical treatment. Based on these observations, we propose a classification scheme for acute fractures (►Table 1). This classification can then provide an algorithm for treatment (►Fig. 7). We do not have enough data to provide specific recommendations for coronal scaphoid nonunions and those with perilunate injuries.

Limitations of this study include the small number of patients and the incomplete follow-up in some of our cases. This is a retrospective study and the natural history of a coronal fracture of the scaphoid is unknown. The mechanism of injury is unclear. It is noted that undisplaced fractures or those treated with anatomic reduction and rigid fixation can maintain a good outcome even at 11 years. Neglected fractures which heal with a malunion or nonunion can lead to radiocarpal OA and secondary wrist pain which requires a salvage procedure, therefore early recognition and appropriate treatment is key.

Conflict of Interest
None.

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